Farming Efficiency and the Determinants of Multiple Job Holding by Farm Operators

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The extent to which farm families engage in off-farm employment activities is a topic of central importance to understanding the financial well-being of farm households. The degree of financial stress experienced by U.S. farm families is always a concern to policy makers. Yet, policy considerations often ignore the substantial involvement of most farm households in nonfarm labor markets. It has been shown that, when the entire farm household is considered, the "average" U.S. farm household has a higher total income and much greater asset holdings than is the case for nonfarm households (see, e.g., Goodwin). Mishra et al. presented data for 2000 suggesting that, when all farms are considered, 92% of total household income came from nonfarm sources. Of course, such figures depend on how one chooses to define a farm. When one considers large and very large commercial farms, the share of farm income in total household income ranges from 50 to 75%.[1] Further, the involvement of farm households in nonfarm employment activities has shown steady growth over the last 50 years. Smith notes that in 1930 about 11% of farmers worked at least 100 days per year off the farm. By 1997, this figure had risen to about 45% with roughly one-third of operators working full time off the farm.

An extensive literature has evolved that investigates the determinants of farm household involvement in nonfarm labor markets. Schultz noted that off-farm employment was an important means by which farm households can manage risk through diversification of income sources. Mishra and Goodwin confirmed the important role of off-farm employment as an avenue for managing the financial risks faced by farmers. A number of studies have also considered various demographic factors relevant to participation in off-farm labor markets, including age, household size, experience, and the presence of small children in the household (see, e.g., Goodwin and Holt; Furtan, Van Kooten, and Thompson; Huffman and Lange; Lass and Gempesaw; and Sumner).[2] In addition, a number of farm characteristics have been shown to be relevant to the degree of participation in off-farm labor markets. Operators of larger farms, farms with year-round labor requirements (e.g., dairies), and the proximity to urban job opportunities have all been shown to be important factors affecting an operator's participation in off-farm labor markets.

As is the case with all labor-supply decisions, factors underlying implicit wages for an agent are likely to determine the extent of their involvement in labor markets. In the case of multiple job holdings, agents will compare options and allocate their labor time so as to maximize total utility, which implies equalizing marginal returns to labor in alternative jobs and in the consumption of leisure. An important point in this regard is that more time spent in one job generally implies less in others. In the case of farming, the increasing significance of off-farm work may imply less labor effort being focused on the farm, at least for those operators with multiple job holdings.

The range of opportunities facing an individual farmer is likely to be determined by their stock of talents and expertise. In general, an individual's stock of human capital and thus their nonfarm marginal wage may be reflected in their formal education, age, and experience working in nonfarm activities. Other operator characteristics, such as the degree of risk aversion and their career aspirations, may play an important role in explaining the observed allocation of their labor effort.

[1] For summary statistics on farm and nonfarm earnings for U.S. farm households, see the USDA-ERS "Farm Income Briefing Room" on the ERS website (www.ers.usda.gov).

[2] For an excellent overview of the literature, see the review paper of Lass, Findeis, and Hallberg.

In light of the increasing prominence of off-farm labor as a determinant of farm household income, concerns have recently been raised about the extent to which time and management expertise may have been pulled away from farming. In a recent paper, Smith poses the interesting question "Does Off-Farm Work Hinder 'Smart' Farming?" She noted that the increased reliance on off-farm employment may have implied less attention to issues important to farm productivity such as adoption of best management practices, integrated pest management, and precision farming. Smith argued that such practices, which she termed "smart farming," are generally expected to lead to a reduction in variable production costs that should outweigh any losses in farm yields. However, to the extent that off-farm employment pulls away on-farm effort, adoption of such technologies may be inhibited and less efficient farming may result.

Herein lies the objective of our analysis. We consider the relationship between farming efficiency and off-farm labor supply. Our goals are twofold. First, we consider the determinants of the off-farm labor supply of a sample of farm operators. In addition to the conventional factors thought to be related to off-farm work decisions, we focus attention on an important intangible factor influencing work decisions—career objectives. An important component of the implicit returns to a labor activity is the psychic satisfaction that an individual may obtain from a particular line of work. Such satisfaction is closely related to career aspirations and goals. Economists are not generally well suited to examine such vague and nebulous concepts. In this case, however, career aspirations are explicitly addressed by means of a survey. A second important objective of our analysis is to evaluate the relationship between off-farm work and farming efficiency. Our analysis was inspired by the questions raised by Smith regarding the extent to which off-farm work may have implications for farming efficiency.

Conceptual Framework

Consider an individual farm operator.[3] Following the approach of Goodwin and Holt, we assume that income-generating options exist in agriculture (supplying F hours of labor

to farming) and through off-farm employment (supplying M hours of labor to the off-farm market). Under conditions of perfect information, we assume that the farm operator maximizes a utility function having leisure (L) and the consumption good (q) as its arguments:

$$(1) \quad U = U(q, L, \kappa)$$

subject to:

$$(2) \quad \mathbf{pq} + \mathbf{r}'\mathbf{X} = wM + P_F Q(\mathbf{X}, K, F) + A$$

$$(3) \quad T = F + L + M, \ \ F \geq 0, \ \ L \geq 0, \ \ M \geq 0$$

where w represents the off-farm wage rate, F represents farm hours supplied, p represents the price of consumption goods, P_F represents the price of farm output (Q), $\mathbf{r}$ is a column vector of prices of other farm inputs and $\mathbf{X}$ is a column vector of other input quantities, and A represents nonlabor income. We allow the utility function to vary according to operator characteristics, which are represented by κ. Farm output is produced according to the production function $Q(\cdot)$ using farm labor, human capital (K), and other farm inputs ($\mathbf{X}$). We assume that the marginal utilities of leisure and the consumption good approach infinity as consumption approaches zero, thus ensuring that positive levels of leisure and the consumption good are always consumed.[4] The Kuhn-Tucker first-order conditions for maximizing the utility function subject to the income, time, and nonnegativity constraints are:

$$(4) \quad P_F Q'_{X_k} - r_k = 0, \quad \text{for inputs}$$
$$k = 1, \ldots, K$$

$$(5) \quad \lambda w - \gamma \leq 0, \quad M(\lambda w - \gamma) = 0,$$

$$(6) \quad \lambda P_F Q'_F - \gamma \leq 0, \ \ F(\lambda P_F Q'_{F_H} - \gamma) = 0,$$

$$(7) \quad U'_q - \lambda p = 0, \quad \text{and} \quad U'_L - \gamma = 0$$

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[3] We abstract from a consideration of joint operator and spouse decisions though such interactions are a topic of current research.

[4] This assumption is common in analyses of labor allocation and eliminates the need for the restrictions ensuring positive levels of L. It is also sometimes assumed (see, e.g., Huffman and Lange) that the marginal productivity of farm labor approaches infinity as the utilization of labor falls to zero, thus ensuring positive on-farm work levels. Note also that, without loss of generality, we make the simplifying assumption that the marginal productivity of other inputs ($\mathbf{X}$) goes to infinity as input use goes to zero, such that a positive level of $\mathbf{X}$ will always be applied.

where λ and γ_i represent Lagrange multipliers for the household's income and time allocation. If an interior solution occurs (implying a nonzero supply of labor to off-farm employment), the first portions of equations (5) and (6) hold as equalities and can be solved to yield the following familiar conditions:

$$(8) \qquad \frac{U'_q}{U'_L} = -\frac{p}{w},$$

which implies that the marginal rate of substitution between leisure and the consumption good is equal to the ratio of the consumption good price to the wage rate, and

$$(9) \qquad P_F Q'_F = w,$$

or that the value of the marginal product of farm labor is equal to the off-farm wage rate. Corner solutions are implied if either on-farm or off-farm labor supply is zero. If we hold the total amount of labor supplied constant, an increase in the price of farm output or an increase in on-farm labor productivity would be expected to result in more labor being supplied to the farm and less to off-farm activities. Likewise, an increase in the off-farm wage rate would result in a lower level of farm employment.[5]

The goal of our analysis lies in providing estimates of descriptive off-farm labor supply decisions rather than explicit estimation of a structural model of labor supply. Thus, we adopt a simple reduced-form modeling approach and relate off-farm labor supply decisions and on-farm efficiency measures to observable farm and operator characteristics reflected in the determinants of wages, prices, and characteristics of the production and utility functions.

Data and Empirical Analysis

Our empirical analysis utilizes data collected under the USDA's 2001 National Agricultural Statistics Service Agricultural Resource Management Survey (ARMS) project. The ARMS survey is a large probability-weighted, stratified survey that collected information from 7,699 farms in 2001. The survey collected detailed information about involvement in off-farm labor markets in 2001. This information also included details regarding producer's risk

Table 1. Major Occupation of Surveyed Farm Operators and Spouses

Major Occupation	Percentage
Operator	
Farm or ranch work	50.30
Hired manager	0.00
Homemaking	1.10
Nonfarm employment	38.23
Retired	10.39
Spouse	
Farm or ranch work	11.88
Hired manager	0.07
Homemaking	28.00
Nonfarm employment	49.90
Retired	10.14

attitudes and career objectives. In addition, the survey annually collects detailed information about a farm operation's costs and returns from agricultural production. We use this information to construct a measure of the farm's overall efficiency (defined as gross cash income over total variable costs).

An important characteristic of the ARMS data relates to the stratified nature of the sampling used to collect the data. Alternative approaches to estimation have been proposed in the literature, including jacknife and bootstrapping approaches.[6] Following Goodwin, Mishra, and Ortalo-Magné, we adopt a bootstrapping approach to consistently account for the stratification inherent in the survey design. The ARMS database contains a population-weighting factor that indicates the number of farms in the population (i.e., all U.S. farms) represented by each individual observation. We utilize this weighting factor in a probability-weighted bootstrapping procedure. The specific estimation approach involves selecting N observations (where N is the size of the survey sample) from the sample data. The data are sampled with replacement according to the probability rule described above. The models are estimated using the pseudo sample of data. This process is repeated a large number of times and estimates of the parameters and their variances are given by the mean and variance of the replicated estimates. We utilize 2,000 replications in the application that follows.

Table 1 presents summary statistics regarding the labor choices made by farm operators

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[5] Under more general conditions, the impact of such changes on overall labor supply depends upon competing income and substitution effects.

[6] In that we use a subset of the overall sample, the jacknife approach may suffer from some limitations. See the discussion in Goodwin, Mishra, and Ortalo-Magné for more details.

Table 2. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Standard Deviation
Hours worked	Annual hours worked off-farm (hundreds)	5.2750	9.2253
Efficiency	Gross cash farm income/total variable costs	1.9256	1.4973
Household size	Size of household	2.9809	1.4994
Acres operated	Total number of acres operated (thousands)	1.4712	3.7498
AMTA payments	Total AMTA payments received ($ thousand)	12.4813	31.3791
Career choice	1 if off-farm employment is career choice, 0 otherwise	0.1370	0.3439
Net worth	Household Net Worth in 2001 ($ hundred-thousand)	11.1622	19.4800
Age	Years of age	53.1144	12.7014
Farm experience	Years of farming experience	25.4916	13.5222
Farm raised	1 if raised on a farm, 0 otherwise	0.8700	0.3363
Miles to town	Miles to nearest town of 10,000 or more	25.9465	25.8720
Risk preferences	Risk preference rating, 1 = risk hating, 10 = risk loving	5.2752	2.3560
Population	2001 population per square mile	109.6460	206.6421
Debts to assets ratio	Ratio of total debts to total assets	0.2023	1.3644
Mean county yield	Average (1996–2001) across crops of county/state yield	0.9988	0.2282
Number of children	Number of children under 13 years of age in household	0.5146	1.0160
Tenancy	Ratio of owned acres to sum of owned and rented acres	0.6255	1.2103
Education	Years of education (imputed from qualitative variables)	13.4319	2.1115
Livestock sales	Ratio of livestock sales to total sales plus government payments	0.3831	0.4308

and their spouses. In the case of operators, 50.3% indicated that their primary occupation was farm or ranch work. In comparison, only 38.2% of farm operators list their primary occupation as nonfarm employment. In contrast, 11.9% of the spouses included in the survey indicated that farm or ranch work was their major occupation while 49.9% indicated that nonfarm employment was their major occupation. We focus our empirical analysis on farm operators. In our sample, 31.7% of farmers worked a positive number of hours in the off-farm labor market.

Table 2 contains summary statistics and definitions for the variables considered in our empirical analysis. A few of the explanatory factors merit special discussion. Our measure of farming efficiency is given by the ratio of gross cash farm income over total variable costs.[7] Other measures of farming efficiency, which

were generally calculated as a ratio of revenues over variable costs, were also considered and found to yield similar results. The Agricultural Market Transition Act (AMTA) payment variable represents the farm's total receipts of production flexibility contract payments under the provisions of the 1996 Federal Agricultural Improvement and Reform Act. These payments were decoupled from any production requirements and instead were based upon historical production of program crops. We are interested in gauging the impacts of the intangible factors embedded in an individual's career ambitions and objectives. Those agents who worked off the farm were asked whether their off-farm job was their career choice. The career choice variable assumes a value of one for those that gave a positive response to this question. The age and years of farming experience of operators were believed to be relevant to labor-market decisions in several respects. More experience on the farm should contribute to more efficiency, at least to the extent that farmers learn by doing. Age is an important demographic indicator of the preferences of individuals. Such effects may be

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[7] Any such measure of efficiency is open to criticism. Of particular concern here is the manner in which survey respondents accounted for farm household labor costs. An alternative measure of efficiency in which labor costs were excluded from total variable costs yielded very similar results, thus tempering any such concerns.

manifest across generations, such that older individuals may have different views and attitudes about employment. An important point to note is that age and experience are highly correlated. The Pearson correlation coefficient between age and experience was 0.75, suggesting that separately identifying their effects may be difficult.

We were interested in representing the extent to which unobservable county-specific characteristics, such as soil productivity, may have been relevant determinants of farming efficiency. To capture such effects, we calculated the average of the ratio of each county's average yield to the state average yield across the principal crops in the county. We then calculated the average of this index over the period 1996–2001. The 2001 ARMS survey asked producers to rate, on a scale of 1 to 10 with 1 representing risk hating and 10 representing risk loving, their aversion to risk. We acknowledge that such a measure of risk preferences, while offering a convenient representation of risk preferences, also has many limitations. The ARMS survey solicits education information by asking individuals to indicate which category (e.g., less than high school, high school diploma, . . . , graduate school) represents their educational achievement. For ease of exposition, we impute years of education values from these responses by assigning a level of education to each category (e.g., less than high school = ten years, four-year college degree = sixteen years, and so forth).

Our model consists of two reduced-form equations representing the off-farm supply of labor by farm operators and the efficiency implied by the ratio of gross sales to variable input costs. We include variables that are conceptually relevant to the efficiency of a farm enterprise. These include the mean county yield variable discussed above; the size of the operation (total acres operated), which is intended to capture scale effects; and tenancy (rented acres as a proportion of total acres). In addition, we hypothesized that certain operator characteristics are also pertinent to the efficiency of farming on any individual operation. These included years of formal education, years of farm experience, and an indicator variable having the value of 1 if the operator was raised on a farm and 0 otherwise. We also include our measure of participation in off-farm labor markets—total annual hours worked off the farm. Of course, we would expect off-farm labor supply to be endogenous to farming efficiency since efficiency is a factor determining the implicit wage for on-farm labor.

The second equation is a standard, reduced-form labor supply equation relating hours of off-farm work to variables pertinent to wages, on-farm productivity (efficiency), and farm and operator characteristics potentially relevant to work attitudes and the costs associated with off-farm work. The corner solution implied in the off-farm labor supply decision also raises the issue of censoring or selection issues. Following much of the literature in this area, we estimate a simultaneous equations version of a Tobit model using the techniques of Nelson and Olsen. It is also of interest to consider endogeneity tests of farming efficiency and off-farm labor supply to one another. Smith and Blundell have shown that an efficient test for endogeneity of right-hand side variables can be obtained by including residuals from a reduced-form equation for the suspected endogenous variable as regressors and testing their statistical significance. We apply the endogeneity tests of Smith and Blundell for Tobit-type regression models.

The equations were estimated jointly using instrumental variable techniques, thus allowing for the joint determination of farming efficiency and off-farm labor supply. As discussed above, we randomly draw from the estimation data using the population probability weights and re-estimate both stages of the model using the instrumental variables techniques. Parameter estimates and summary statistics, calculated from the replicated parameter estimates, are presented in Table 3.

An important finding is that greater involvement in off-farm labor markets does indeed appear to decrease on-farm efficiency. This finding would appear to support the contentions of Smith that off-farm work may have implications for the efficiency of farming. The coefficient suggests that an additional 1,000 hours of off-farm work effort tends to lower the efficiency ratio by about 0.17. Such an effect, though small, is statistically and economically significant. Surprisingly, the effects of the county-level average yield and total acres operated are not statistically significant. In what may seem to be a counterintuitive finding, greater farm experience appears to be negatively correlated with farming efficiency. However, as we have noted above, experience is highly correlated with age. Previous research (Goodwin and Schroeder) has demonstrated that older farmers may be less likely to adopt new technologies and thus may fail to realize

Table 3. Parameter Estimates and Summary Statistics

Variable	Estimate	Std. Error	*t*-ratio
	Farm efficiency		
Intercept	2.2430	0.3091	7.26*
Hours worked	−0.0171	0.0031	−5.42*
Mean county yield	−0.2242	0.1466	−1.53
Acers operated	0.0206	0.0352	0.58
Tenancy	0.0242	0.0225	1.07
Farm experience	−0.0144	0.0028	−5.16*
Education	−0.0102	0.0138	−0.74
Farm raised	0.3856	0.0697	5.53*
R^2		0.0292	
Smith-Blundell test of hours		17.4283	(0.0000)*
	Hours worked off-farm		
Intercept	17.5629	3.8129	4.61*
Household size	0.4808	0.2614	1.84*
Number of children	−1.0262	0.3590	−2.86*
Career choice	18.5394	0.7430	24.95*
Education	0.5959	0.1294	4.61*
Efficiency	−2.3003	1.2804	−1.80*
Risk preferences	0.1178	0.1091	1.08
Net worth	−0.1875	0.0878	−2.14*
Debts to assets ratio	−0.2678	1.1882	−0.23
AMTA payments	−0.2139	0.0949	−2.25*
Age	−0.4128	0.0258	−15.97*
Population	−0.0061	0.0020	−3.06*
Miles to town	−0.0085	0.0138	−0.61
Acers operated	−1.0602	0.8885	−1.19
Livestock sales	1.1413	0.6457	1.77*
Pseudo R^2		0.1289	
Smith-Blundell test of efficiency		2.7142	(0.0995)*

*Indicates statistical significance at the $\alpha = 0.10$ or smaller level. Numbers in brackets are χ^2 probability values.

certain efficiency advantages that come with technological advances. Thus, our finding of a negative correlation between experience and farming efficiency is not unexpected. Education does not have a significant effect on farming efficiency. However, individuals raised on a farm do have a very clear efficiency advantage. This likely reflects the intangible abilities that are imparted through the experiences of growing up on a farm.

Table 3 also contains estimates of the labor supply equation. Of course, in light of the censoring, marginal effects are not directly represented by the coefficients. An approximation to the marginal effects can be obtained by scaling the coefficients by the proportion of observations that are noncensored (about 0.32 in our case).[8] The off-farm labor effort of farm oper-

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[8] To be precise, marginal effects are given by the product of the coefficient and the normal cdf, evaluated at a given observation (typically at the data means).

ators appears to increase as the household size rises. This may reflect labor-supply advantages in larger households. At the same time, the presence of children under the age of thirteen years in the household significantly reduces the supply of off-farm labor. Such an effect is typically confirmed for spouses though expectations for farm operators (typically heads of households) are less clear.

An interesting finding pertains to the career choice variable. Recall that this variable takes a value of 1 if an individual is working off the farm in a field consistent with their career objectives. Career objectives are important in determining the allocation of labor effort for farm operators. Such concepts are, of course, difficult to quantify and measure, especially in an economic context. However, psychic factors such as ambitions and career objectives clearly play an important role in shaping labor and leisure time allocations. In contrast to farm efficiency, education has a strong

effect on the supply of labor to off-farm employment opportunities. Each additional year of education raises the annual supply of labor by more than fifteen hours (for the entire sample).

As expected, farming efficiency has a negative and statistically significant effect on off-farm labor supply. This is consistent with the results for the farming efficiency equation, indicating a negative relationship between off-farm labor supply and on-farm efficiency. Farm operators that are more efficient on the farm tend to supply less labor to off-farm employment alternatives. This finding is consistent with our conceptual model, which predicted that a higher implicit farm wage (i.e., more efficiency) would tend to lower off-farm labor effort. The Smith and Blundell test of endogeneity was conducted and again indicated joint determination of off-farm labor supply and on-farm efficiency. Again, these results are consistent with the arguments of Smith pointing to an inverse relationship between off-farm work and farming efficiency.

The results do not indicate an important role for operators' self-assessed risk preferences in determining off-farm labor supply. Similarly, the debt to asset ratio is not significant, suggesting that leverage effects do not have an important influence on off-farm labor supply. However, the overall net worth of a farm household does have an important negative influence on off-farm labor supply. This may reflect a lower degree of the financial pressure suggested as a reason for more off-farm work by Mishra and Goodwin. Similarly, this may be consistent with a backward-bending labor-supply function or a scale effect. An interesting finding pertains to the effect of decoupled government transfer payments on off-farm labor supply. Farms receiving large AMTA (production flexibility contract) payments tend to supply less labor to off-farm employment options. Again, this may reflect wealth or scale effects that tend to inhibit the supply of labor off the farm.

Older farm operators are less likely to work off the farm. This result is consistent with much of the literature on off-farm labor supply. The lower propensity to work off the farm by older operators may reflect differences in attitudes regarding work that are correlated with age. A surprising result is that farm operators in counties with larger populations appear to supply less labor off the farm. One would anticipate that job options would be better in more populous areas though this may reflect differences

in other farm characteristics in more densely populated regions. Miles to the nearest town, a factor representing the costs of commuting to a job, do not appear to significantly influence the supply of labor off the farm. Finally, operators of farms with more relative livestock sales appear to supply more labor off the farm than is the case for crop farmers. This may reflect differences in labor requirements for such operations though the fact that many livestock operations require year-round labor would suggest a negative effect on labor supply.

Concluding Remarks

Our analysis has considered factors relevant to the division of labor between on-farm and off-farm employment alternatives. We have focused our analysis on the relationship between farming efficiency and off-farm labor supply. Our results confirm an important and statistically significant inverse relationship. More intensive participation in off-farm labor markets tends to be associated with lower farming efficiency. Such a relationship was hypothesized by Smith who noted that off-farm work may hinder "smart farming." Similarly, we confirm a negative effect of farming efficiency on the supply of labor to off-farm employment alternatives. As theory would predict, more efficient farmers are less likely to work off the farm. This reflects a higher implicit farm wage for such operators. We used the endogeneity tests of Smith and Blundell to consider the extent to which farming efficiency and off-farm labor supply were jointly determined. The tests suggested that each variable is endogenous to the other, thus confirming that off-farm labor supply and farming efficiency are jointly determined.

Important research questions remain unanswered by this research. We have ignored the important role of spousal labor supply decisions. A large body of research has confirmed important relationships involving the joint determination of labor supply decisions by farm operators and their spouses. Future research will consider these interactions and their relationship to farming efficiency.

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